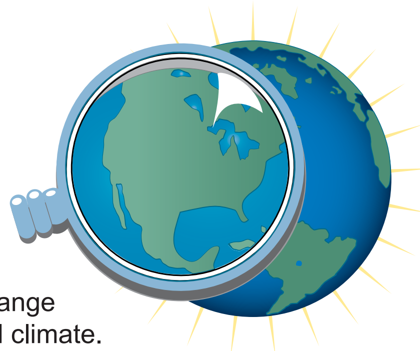
How do water bodies change over time?



Investigation Overview

Students explore how water bodies change in response to changes in weather and climate. They do experiments to demonstrate the effect of rising sea level on coastlines. They also use NASA images to examine dramatic changes in water levels in a river system in the United States and a lake in Africa.

Time required: Three 45-minute sessions

Materials/Resources

NASA images (transparency of each and four copies each of Figures 5, 6, and 7)

Figure 1: Mountainous coastline in California
Figure 2: Flat coastline in the Eastern United States
Figure 3: Greenland
Figure 4: Map of Midwestern flooding
Figure 5: The Mississippi River System in 1988
Figure 6: The Mississippi River System during the 1993 floods
Figure 7: Lake Chad, 1973 and 1997 (Note: hard copies must be in color)
Figure 8: Grid (one transparency to project and one transparency for each group of students)

Two preferably clear, rectangular baking pans, any size,
Clay
Water
Sand or soil
Two blocks of ice frozen in a full sandwich-size Ziploc bag
For each group of 2 to 4 students:

- One sheet tracing paper
- A fine black marker
- A sharp pencil
- A sharp light blue crayon
- An atlas (with U.S. landform map)

Log 1: Our coasts
Log 2: Greenland
Log 3: Flooding in the Midwest—Background
Log 4: Flooding in the Midwest
Log 5: Lake Chad is shrinking
Two overhead projectors
NASA background information: DAAS, "Distributed Active Archive Centers" "Meltdown," "Ramping Up," "Eye on the Ocean," optional

Geography Standards

Standard 7: Physical Systems

The physical processes that shape the patterns of Earth's surface

- Explain how physical processes help to shape features and patterns on Earth's surface.

Standard 18: The Uses of Geography

How to apply geography to interpret the present and plan for the future.

- Identify ways in which geographic conditions change.

Geography Skills

Skill Set 4: Analyze Geographic Information

- Use texts, photographs, and documents to observe and interpret geographic trends and relationships.
- Use simple mathematics to analyze geographic data.

Skill Set 5: Answer Geographic Questions

- Use methods of geographic inquiry to acquire geographic information, draw conclusions, and make generalizations.

Content Preview

Like everything else on Earth, bodies of water change. NASA monitors such changes using remote sensing. Water bodies change because of global warming, erosion, drought, human modifications (e.g., diverting water and building dams that result in a depletion of water supplies), and natural events such as floods and hurricanes. As Earth's temperature warms and ocean levels rise, large population concentrations may be affected. Related climate change and seasonal differences in precipitation affect water bodies like Lake Chad in Africa.

Classroom Procedures for Day 1

Beginning the Investigation

1. Ask students to think about change that they can see. What changes and why? List their responses on the chalkboard. (*Changes in people, in the landscape during different seasons, in the position and phases of the Moon, etc.*)

2. Write the phrase "Earth Changes" on the chalkboard and refer back to the list made in #1. Find the changes that were described that affect Earth and discuss how we can find out about changes that occur at different scales: local, national, and global. (*Written information, aerial photographs, satellite images, etc.*) Tell students that part of NASA's mission is to monitor changes on Earth to help us understand changes in our environment.

3. Discuss with the class the ways in which water bodies may change over time and the reasons for such changes. Be sure that the following causes are addressed:

   - Warming trends during which ocean water expands and glaciers melt
   - Erosion caused by national forces and human/environmental modifications
   - Drought
   - Human modifications such as diverting water, building dams, depleting water supplies
   - Natural disasters, hurricanes, floods

   Tell students that this lesson will focus on changes in water and water bodies and on the impacts of such changes.

Developing the Investigation

4. Project **Figure 1** and explain that this NASA image shows the coast of southern California. Ask students which ocean borders this coast. (*Pacific.*) Can they tell if the coast is mountainous or flat? NASA has helped us see the mountain ranges by adding shading and color to the image.

5. Project **Figure 2** and explain that this is an image of the east coast of the United States. Ask students to identify the ocean in this image. (*Atlantic.*) If the class has completed **Investigation 2** in this module, they should be able to identify Chesapeake Bay.

   Ask the students if this coastline is flat or mountainous. How can they tell? The Coastal Plain is a lighter shade than the Piedmont region (the foothills between the Coastal Plain and the Appalachian Mountains). Have a student draw a line on the transparency marking the western edge of the Coastal Plain. Have the class identify beaches and barrier islands.

6. Speculate about how changes in sea level would affect these two coastlines, and lead students to realize that the mountainous coast would experience less flooding because of the higher elevations and steeper sloping coastline.

7. Do the following experiment to demonstrate how the change in water level can affect the coastline. This can be done as a class project or in smaller groups.

   A. Put a layer of clay at the bottom of a baking pan. Ask students to mold mountains from clay and to create a coastline of mountains. Arrange the mountains along half of the clay bottom. Tell the students that the clay bottom represents the land that is covered by the ocean.

   B. Have a student pour some water into the bottom of the baking pan. Talk about what will happen to the shoreline as sea level rises. Mark a line in the clay mountains to show sea level after this first application of water. Have two more students add water to the pan and make new lines in the clay to show the changing sea level. Ask students to give reasons why water level might rise. (*Ice caps may melt as Earth warms.*)

   C. Create a different landscape in the second baking pan. Have students cover the bottom of the baking pan with a gently sloping layer of clay. Add another gently sloping layer of clay in half of the pan. Ask students to talk about this landform. Have a student pour water in the lowest part of the pan. Mark a line in the clay coast at the water level. Ask students to predict what will happen as sea levels rise. Pour more water into the "ocean" and watch the flooding when the sea begins to cover the landscape. Save the two landscapes for concluding activity for Day 1.

8. Distribute **Log 1** and have a student read the information on coastlines to the class. (This information can be read to younger students.) Ask the following questions.

   - What are coastlines? (*Where oceans or other large water bodies meet land.*)
   - What causes coastlines to change? (*Force of waves and currents, lava entering the sea from land, depositing of sediment, sea level rising and falling.*)
   - How much has the sea level risen in the past 100 years? (*30 centimeters.*)
   - What portion of the world's people live within 80 kilometers of a coast? (*More than half.*)
   - How will the rise of sea level affect coastal cities? (*Lowland cities will be flooded.*)

   Have students work in groups to answer the questions in **Log 1**. Each group will:
   1) locate a landform map of the United States in the atlas,
   2) identify two cities on mountainous coastlines and two cities on flat coastlines,
   3) assess the impact of a significant rise in sea level on the region in which each city is located. It is important to stress that they are looking at the region rather than the city itself. A city could be in a mountainous area but still be located entirely on a narrow and flat coastline.

   Then ask each group to report their findings to the class.

9. Share with students that NASA scientists are concerned about sea level rising and that Greenland is being studied to track changes in the melting ice sheet. Locate Greenland on a map, then project **Figure 3**. For grades K–2, discuss the information in **Log 1** while examining this photo, taken by an astronaut on the Space Shuttle.

   For grades 3 and 4, discuss the photo, pointing out the extent of the ice cover. Make sure students can tell the difference between the ice and the clouds. Distribute **Log 2** and have students work in pairs to read the background information and answer the questions. Share responses.

   With all grades, talk about what impact continued melting of Greenland's ice sheet could have on coastal areas.

Concluding the Investigation

10. Show the ice in Ziploc bags. Ask students to predict what would happen to the two coastline landscapes that they created if some of the ice melted into the ocean. Take the ice out of the bag and put it on the clay landscapes. Mark the water level on the coastline with a line. Have the landscapes sit overnight and measure changes in the sea level at the next class.

Classroom Procedures for Day 2

Beginning the Investigation

1. Look at the changes in the coastline clay activity and talk about why it is important to look at images of the same location over time. Project a transparency of **Figure 4**. Explain that the map has been drawn on a satellite image to give a realistic view of the land. Have students read the names of the rivers and the states. Leave the transparency on the screen for the rest of this activity. Explain that an unusual amount of rain made these rivers flood their banks in 1993, causing a great deal of damage to the surrounding land. Many farms and towns were flooded, and many people lost their homes.

Developing the Investigation

2. Project **Figure 5** and **Figure 6** using two projectors. Help students figure out 1) that these are satellite images taken before and after the flooding, and 2) that such images can help us calculate the extent of the flooding and predict the downstream movement of the floodwaters.

3. Divide the class into groups of four. Give each group a copy of **Log 3** and **Log 4** and a hard copy of **Figure 5** and **Figure 6**. Have students take turns reading the background information in **Log 3**, then have each group discuss the questions in **Log 4** and come to some agreement on the answers. Students can take turns recording the answers. Go over the questions with the class and ask the groups to share their responses. Question 4 should lead to some speculation about measuring the width of the flooded area with a ruler and comparing it with the width of the river channel.

4. Locate the region on a physical map of the United States. Note the relatively flat landscapes surrounding the rivers. Raise questions about what causes rivers to rise (*heavy rainfall*) and what types of landscapes would more easily be flooded (*flat land*).

5. Give each group tracing paper, a fine black marker, a sharp pencil, and a light blue crayon. Explain that they will work together to make a map that shows how much of the land along the rivers was flooded in the Midwest in 1993. Have each group follow these instructions:

   A. Tape the tracing paper over **Figure 5**.
   B. Take turns using the pencil and a ruler to draw a box around the area in the image, following the edges of the image.
   C. One student will make a circle with the black marker to show the location of St. Louis, and then draw a very fine line with the same marker along the Mississippi River south from St. Louis.
   D. Each of the other three students will use the marker to draw fine lines along the Mississippi River north of St. Louis, the Illinois River, and the Missouri River. Do not label the rivers yet.
   E. Now move the tracing paper to **Figure 6**, line up the box and the rivers on the tracing paper with the image, and tape the tracing paper in place.
   F. Each student will return to his/her part of the river system and use a sharp pencil to outline the flooded areas. This will produce a map that shows the original channels in black marker and the edges of the flooded areas, on either side of the rivers in most cases, in pencil. Students can complete the map by very lightly coloring the flooded areas with a blue crayon. They should be sure that the black line marking the original channel shows clearly. Then they can label their parts of the river system and the city of St. Louis.

Concluding the Investigation

6. Keep students in their groups and give each group a copy of **Figure 7**. Project the transparency of this figure. Explain that these are satellite images of an important lake in Africa that many people depend on for water. It is on the border of the Sahara Desert in a region that is very dry.

7. Have students find Africa, the Sahara Desert, and Lake Chad on appropriate maps. Ask them to identify the countries that border the lake. Explain that the water in Lake Chad comes mainly from a river named the Chari, which flows from places to the south that receive more rainfall than the region around the lake. Point out the Central African Republic on the map as the source of the Chari River. In the Central African Republic, most of the rain falls in the summer and little falls in the rest of the year. If the summer is wet in the Central African Republic, Lake Chad fills up with more water in the fall. Why in the fall? Have the students figure out that it takes that much time for the rainwater to drain into the river and for the river to carry it north to Lake Chad.

   What happens when summers are drier than usual in the Central African Republic? Lead the students to conclude that there is less water in the Chari River and that less water comes into Lake Chad in the fall. This has been the case for the past three decades because in this part of the world the climate has become drier. In addition, water has been diverted from the river for irrigation, further reducing the flow into the lake.

   Water evaporates from the lake all year because of the hot, dry climate, and if the water is not replenished during the fall to compensate for the evaporation, the lake becomes smaller and smaller. As the water becomes shallower along the shores, plants appear on the emerging lake bottom, creating large marshes, or wetlands, that gradually become dry land as the lake becomes smaller.

8. Have the class examine the images of Lake Chad in the transparency. Point out that the blue areas are water and that the speckled areas are wetlands. Plants that are very lush and green are shown here as red to make it easier to see where the vegetation is. In this dry environment, the only plants that can grow well are in the wetlands around the lake. Why is this? (*They have plenty of water. Farther from the lake, the wetlands are drying out as the lake shrinks.*)

9. Discuss the change between 1973 and 1997 in the amount of water in the lake and in the amount of wetlands. Lead the class to conclude that much of the area that was under water in 1973 is now wetland. As the wetlands gradually turn into dry land, local farmers use it to grow crops. Younger students should conclude the investigation at this point, while fourth graders may continue.

10. Divide the class into groups and give each group a copy of **Figure 7** and a transparency of **Figure 8**. Remind the class that satellite images made at different times can be used to measure changes in the environment. Explain that they themselves can figure out how much smaller Lake Chad was in 1997 than in 1973, and how much the wetlands expanded during that time. Make sure that they understand the following procedure.

Each image contains a square that is 20 kilometers on each side, or 400 square kilometers. Help students understand this concept. You can measure the size of the lake by seeing how many of these 400 square kilometer squares you can place on it. The easiest way to do this is to place a grid of squares over the images. Demonstrate this to the students by placing the transparency of **Figure 8** (Grid) over that of **Figure 7** (Lake Chad), so that the grid covers the image of the lake in 1973. Point out that they can count the number of squares that are on water. Then move the grid to the 1997 image and show the class that far fewer squares are on water.

If the area under the square is more water than wetland, they will count it as water, and if it is more wetland than water, they will count it as wetland.

11. Distribute **Log 5**, and help each group to follow the directions to calculate the change in the size of the lake and the wetlands. The interpretations will vary, given the necessarily gross estimates and the students' lack of experience interpreting images, but the final conclusion should be that there was a drastic reduction in the surface area of the lake. This is a useful measuring procedure that can be refined as students are able to handle more complex interpretations.

Background

Glaciated terrain

Glaciers are large masses of ice that are usually 200 meters or more thick. Because they move so slowly, you cannot see them move, but these big heavy masses flow and shape the landscape. There are two types of glaciers, valley glaciers and continental glaciers. Valley glaciers form high in mountains, filling in narrow mountain valleys and widening them as the ice moves slowly downhill. If a valley glacier reaches the sea, parts may break off and form icebergs.

A continental glacier is a thick dome of ice that covers a large area, the size of part of a continent. Continental glaciers are also called ice caps or ice sheets. The weight of the ice causes it to flow very slowly from where it is deepest toward the margins of the ice sheet. When continental glaciers melt, they leave behind altered landscapes. The moving ice takes with it soil, rocks, boulders, and anything else that it can pry loose and move across the landscape. All this loose material is deposited as the ice stops moving and begins to melt near the margins of the ice sheet. In mountainous areas, continental glaciers erode the mountain slopes in much the same way valley glaciers do.

Evaluation/Key

Log 2: Greenland

1. 1/5
2. By comparing older and newer satellite images.
3. It causes the sea level to rise.

Log 5: Lake Chad is shrinking

Note that there are no "correct" answers. They will vary depending on how the squares are initially positioned and how the vegetation is interpreted.

Additional Resources

http://southport.jpl.nasa.gov/pio/srl/sirc/srl-patagonia.gif
Patagonia

http://sdcd.gsfc.nasa.gov/GLACIER.BAY/glacierbay.story.html
Glacial changes, work done by NASA geographer, Dorothy Hall

http://www.nasm.edu/ceps/RPIF/LANDSAT/LIMG/24_37.gif
Landsat image north of Vicksburg, Mississippi, showing Mississippi River floodplain

http://observe.ivv.nasa.gov/ *Educator's guide to Earth—The ever-changing planet*, images of Earth to identify and illustrate ways that Earth changes

http://www.nasm.si.edu/earthtoday/quakelg.htm Western Hemisphere quake zone

Make It Work! Rivers: World Book, Chicago, 1996

Make It Work! Oceans: World Books, Chicago, 1997

CD-ROM, *Visit to the Ocean Planet,* NASA educational product

Module 2, Investigation 4: Log 1

Our coasts

The coast is where the ocean meets land. Coastlines are always changing their shape. They are being worn away in some places and built up in others. Coasts can wear away due to the force of waves and currents. Coasts can build up when sediment (sand, gravel, etc.) is carried from one spot to another. They can also be built up when lava enters the sea from land.

Coastlines also change as the sea level rises and falls. Average sea level has risen about 30 centimeters in the last 100 years. Earth's atmosphere has warmed up slightly, causing some of the ice in the polar regions to melt. Meltwater has returned to the oceans, and sea level has risen. Another reason for the rising sea level is that the oceans are also warmer, and as the water becomes warmer it expands.

More than half of the people in the world live within 80 kilometers of a coast. Many large cities are near the coast. London, New York, and New Orleans are examples. What will happen to these coastal cities if sea levels continue to rise?

1. Look in your atlas and find two large U.S. cities that are on flat coastlines and two that are on mountainous coastlines.

2. Name the cities and the oceans that they border.

   Flat Coastlines:
   City 1: ____________________________ Ocean____________________________

   City 2: ____________________________ Ocean ____________________________

   Mountainous Coastlines:
   City 3: ____________________________ Ocean____________________________

   City 4: ____________________________ Ocean ____________________________

3. Think about how the *region* around each city would be affected by a rise in sea level of several feet. Which two *regions* would have the most widespread flooding?

   The regions around _________________________ and _________________________.
   Write a sentence to explain your answer.

   ____

Module 2, Investigation 4: Log 2

Greenland

In much of the world, sea level is slowly rising. One important reason for this seems to be that some of the world's ice is melting and adding water to the oceans.

Most of our planet's ice is found in thick sheets that cover the land in places where the climate is cold. The largest ice sheets are in Antarctica and Greenland. If these ice sheets melt, they will add so much water to the oceans that most of the world's coastlines will be flooded.

About 4/5 of Greenland is covered by ice that is up to 3,000 meters thick. Some of the ice always melts in the summer. But summers are short there, and winters are long. During the winter, the falling snow packs down to form new ice. If the amount of ice that melts in the summer is the same as the amount of ice that forms in the winter, the ice sheet stays about the same size. If the amount of ice that melts is greater than the amount that forms each year, the ice sheet shrinks.

NASA scientists discovered that some of the ice along Greenland's coastline disappeared during the last few years. How did they find this out? They compared satellite images from 1993 with images from 1999. By measuring the changes in the ice sheet, they could tell how much of the ice had melted.

Does this mean that the ice will continue to melt? We cannot be sure yet. But the scientists will continue to compare new satellite images with older ones. Over time, they will see if the ice sheet keeps melting. If it does, the images will help them figure out how fast it has been melting. Then they can use that information to predict how fast the ice will melt in the future.

Use the information about Greenland's ice sheet to answer these questions.

1. If 4/5 of Greenland is covered by ice, how much is not covered by ice?

____

2. How can scientists tell if the ice sheet is melting?

____

3. Why is it important to know if Greenland's ice sheet is melting?

____

____

Module 2, Investigation 4: Log 3

Flooding in the Midwest—Background

Directions: Read this information to learn more about river flooding. Answer the questions on Log 4. You will share this information with the class.

Satellite images were used to help people during serious flooding in 1993. In the Midwest, heavy rains caused the waters of the Mississippi, Missouri, Illinois, and several smaller rivers to overflow their banks. Communities and farms along the rivers were in danger of being flooded.

Officials in the city of St. Louis, Missouri, needed a plan to evacuate people and property as the waters of the Mississippi River rose toward the top of the river bank. Mr. Lee Blackmore, who worked for the city, used satellite images and maps to help plan the evacuation.

"The water is rising fast," said the frantic voice on the telephone. "Can you help with the evacuation? We're losing our race against the river." Mr. Blackmore went to work. He knew the city was running out of time and that homes and businesses along the river would soon be flooded.

The St. Louis police department had been ordered to start evacuating neighborhoods that might be in danger. But these areas had seldom flooded, so many residents remained in their homes, believing they were safe.

Mr. Blackmore helped make a map from satellite images of the flooding. It clearly showed the police where the flood waters were rising fast. The successful evacuation began within four hours after Mr. Blackmore received the call for help.

Many people were affected by the flood waters, but no lives were lost.

Figure 5 shows the St. Louis area during the dry summer of 1988. The river, in black, is narrow and runs in its normal channel. Vegetation is in green; dry soil and urban areas are shown as red and brown. Figure 6 shows the river system in full flood in July 1993.

Can you see just where the river went over the banks?

http://observe.ivv.nasa.gov/nasa/exhibits/flood/flood_2.html

Module 2, Investigation 4: Log 4

Flooding in the Midwest

Directions: Look at your two images very carefully. How are they different? Read the information about the images and answer the following questions.

1. Titles of the images

   Figure 5 ____________________

   Figure 6 ____________________

2. In which year was each image made? Figure 5 __________ Figure 6 __________

3. What changes can you see in Figure 6? ____________________

4. How could you measure these changes? ____________________

5. What could happen to people, animals, and the rest of the environment because of these changes? ____________________

6. Why do you think the changes occurred? ____________________

7. Look at a map to find the location of your images. Which states are shown in the images?

8. Which two rivers join in the Mississippi River just north of St. Louis?

   ____________________ ____________________

Module 2, Investigation 4: Log 5

Lake Chad is shrinking

Directions: Your group will use satellite images of Lake Chad to figure out how the lake changed in size between 1973 and 1997.

Place the grid (Figure 8) over the 1973 satellite image of Lake Chad (Figure 7). Take turns counting the number of squares that are on water in each numbered row. If the square falls partly on water and partly on wetland or dry land, use the following rule: If more than half of the square is on water, count it as water. If less than half the square is on water, do not count it as water. Remember that wetland is not water!

Take turns placing this information on the tally sheet below. Then do the same for the 1997 image.

Tally Sheet (Row)	1973 Image	1997 Image
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

1. How many water squares did you count in 1973? ____________ In 1997? __________

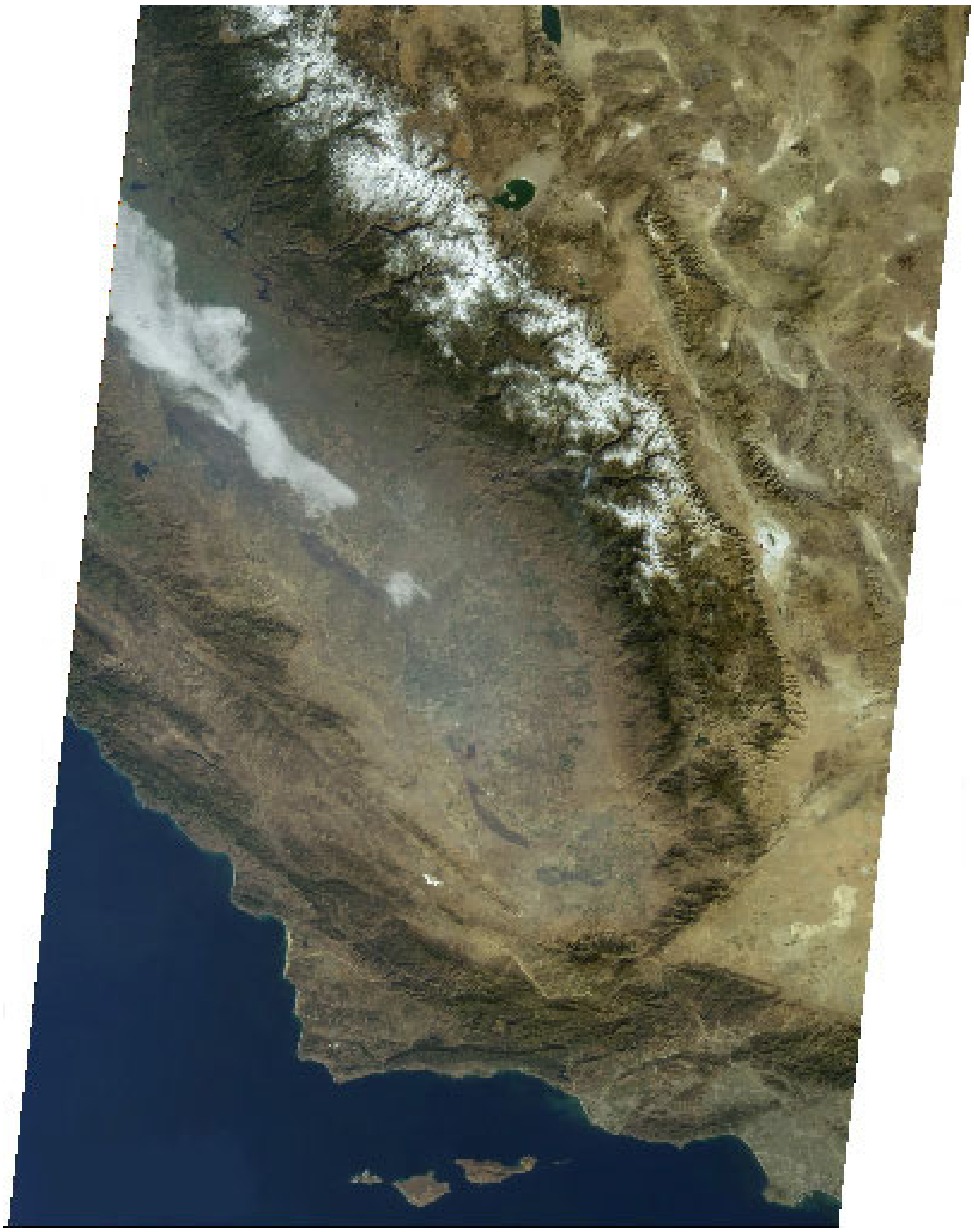
2. Each square represents 400 square kilometers. How many square kilometers

   was Lake Chad in 1973?_____________________ In 1997? ______________________

3. How much smaller was Lake Chad in 1997 than in 1973?

   ____________________________square kilometers

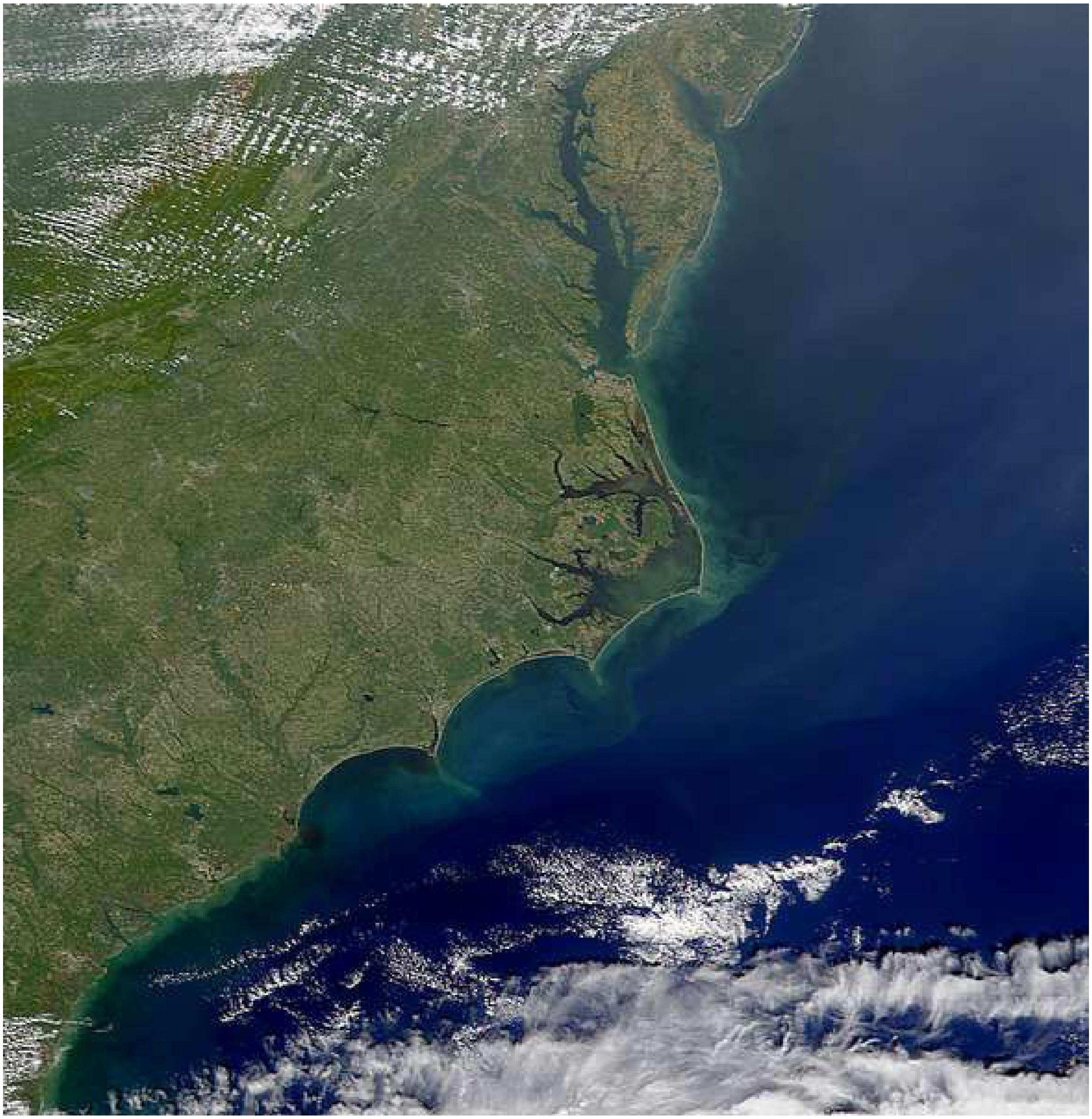
Module 2, Investigation 4: Figure 1
Mountainous coastline in California



Source: http://visibleearth.nasa.gov/cgi-bin/viewrecord?7546

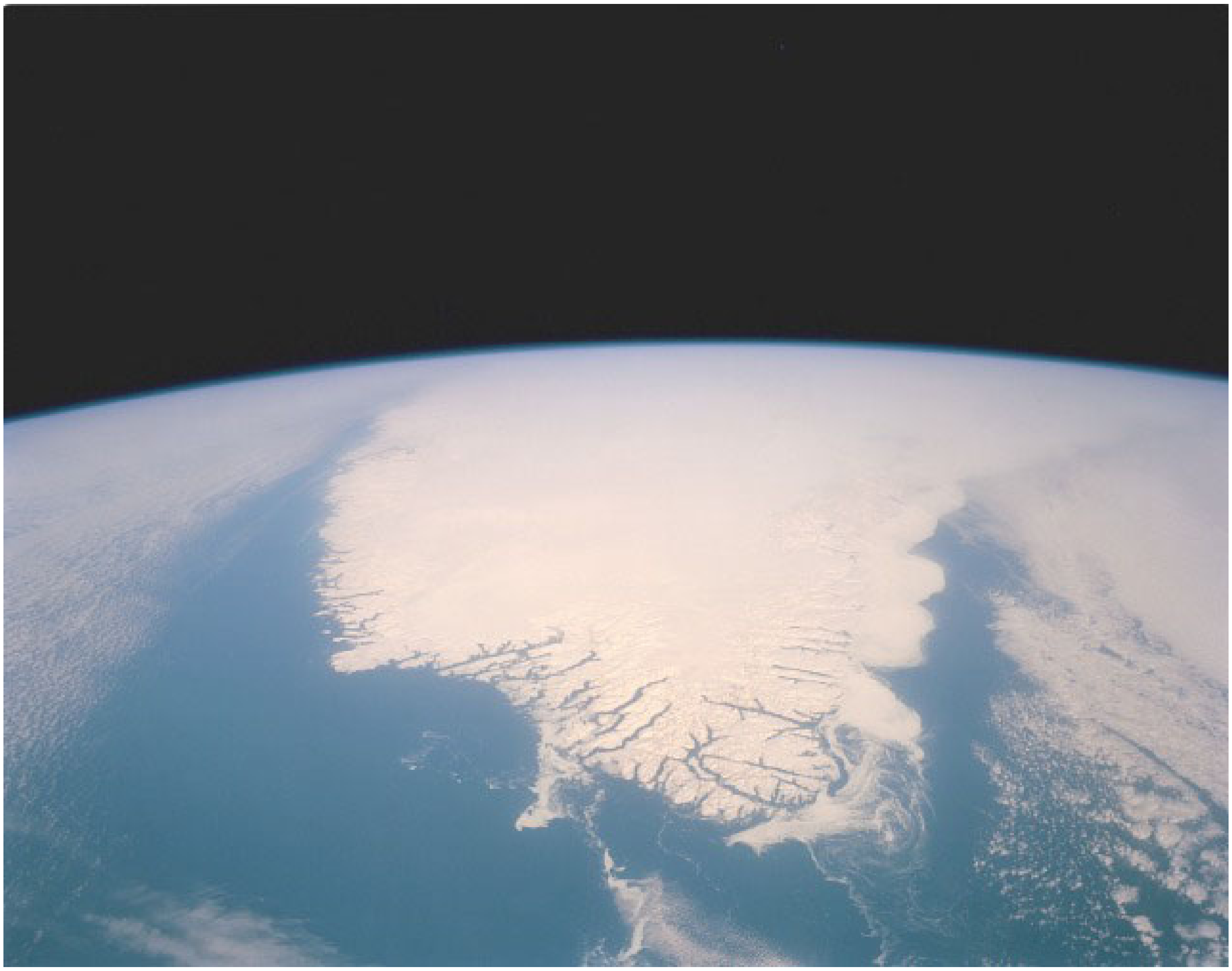
Module 2, Investigation 4: Figure 2

Flat coastline in the Eastern United States



Source: http://visibleearth.nasa.gov/data/ev51/ev5144_S2000277172549_md.jpg

Module 2, Investigation 4: Figure 3
Greenland



Source: earth.jsc.nasa.gov/photoinfo.cgi?PHOTO+STS045-152-105

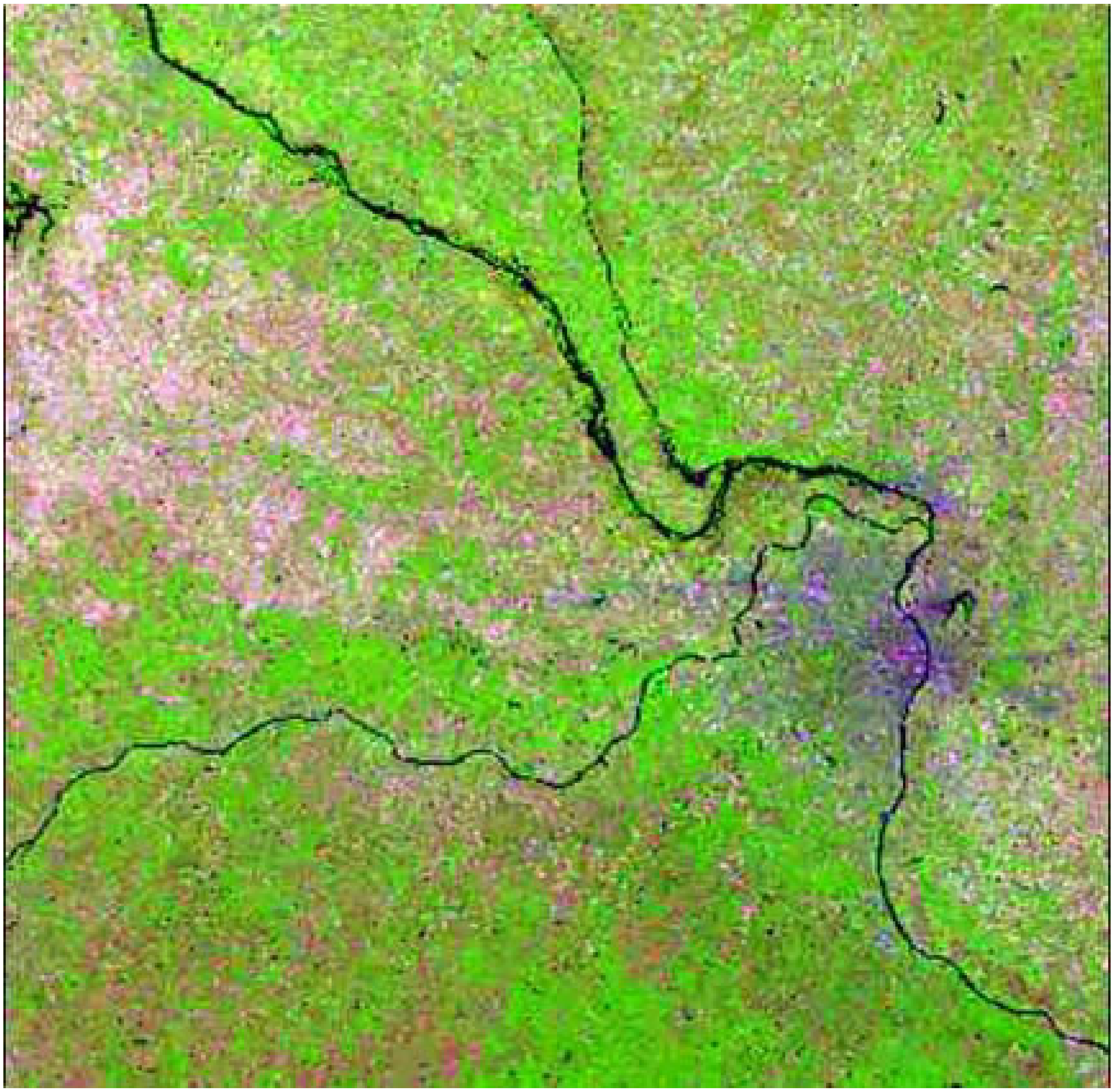
Module 2, Investigation 4: Figure 4

Map of Midwestern flooding

Source: http://observe.ivv.nasa.gov/nasa/exhibits/flood/flood_2.html

Module 2, Investigation 4: Figure 5

The Mississippi River System in 1988



Source: http://observe.ivv.nasa.gov/nasa/gallery/world/graphics/flood1.jpg

Module 2, Investigation 4: Figure 6

The Mississippi River System during the 1993 floods

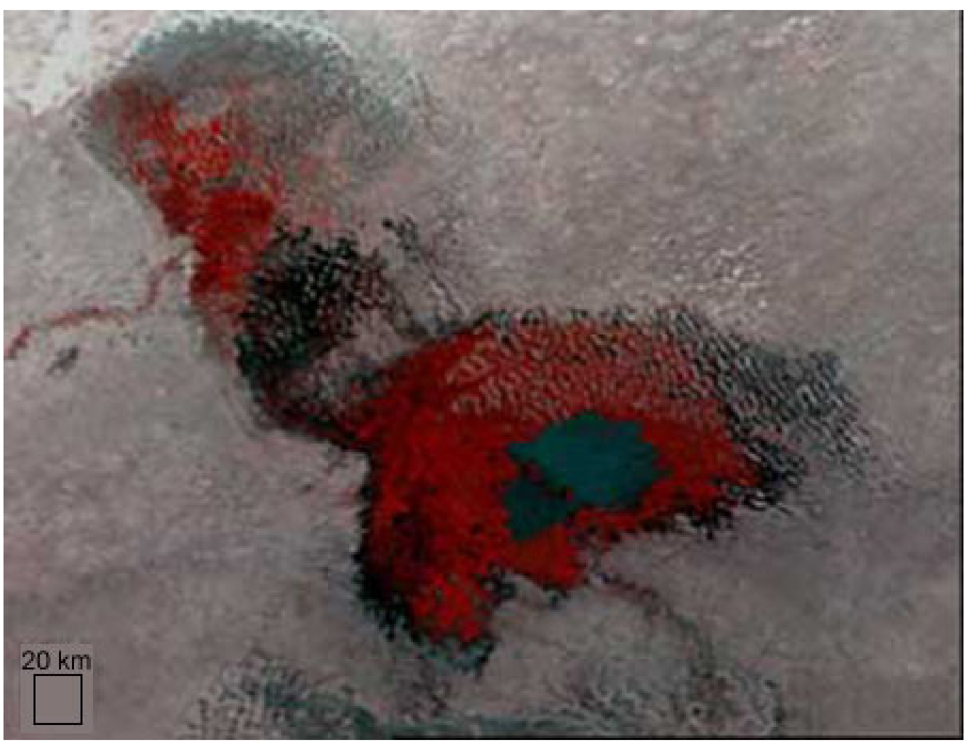
Source: http://observe.ivv.nasa.gov/nasa/gallery/world/graphics/flood2.jpg

Module 2, Investigation 4: Figure 7

Lake Chad, 1973 and 1997

Image 1: January 1973

Image 2: January 1997



Source: http://www.gsfc.nasa.gov/gsfc/earth/environ/lakechad/chad.htm

Module 2, Investigation 4: Figure 8
Grid